ISTS 94-f-08

INTERNATIONAL DEEP SPACE COMMUNICATIONS AND SCIENCE NETWORK

Nicholas A. Renzetti, Ph.D
Jet Propulsion Laboratory
California Institute Of Technology
Pasadena, California

Abstract

This paper proposes extending NASAs Deep Space Network into a 6-station International Network. Discusses the design rationale with these characteristic: Avoids loss of communications due to natural hazards; earthquakes, etc; provides latitude diversity to cover significant mission event s wherever they occur; provides additional stations to cover events in high southern latitudes. Proposal extends to ground facilities those international agreements now existing for space vehicles; considers use of Russian deep space complexes as available facilities; and is consistent with the current proposal for an international Mars exploration program. Network could support mission operations centers throughout the world.

Introduction

This paper presents the rationale, particularly for the Science Community, for an 'International Deep Space Communications and Science Network to meet the challenges of the future. It assumes that the cold war being over, the nations of the world will cooperate in carrying out joint deep space missions. We propose that the stations beyond the existing NASA Deep Space Network be implemented, maintained and operated by the relevant space agencies. Candidate sites are discussed later in this paper.

We are already partners with other nations in providing science instruments, spacecraft elements, and launch vehicles, but have not yet taken any step toward establishing an international network.

The need to take this step is presented dramatically in the remarks of two leading exponents of the U.S. space program.

REMARKS BY THE HONORABLE
GEORGE E. BROWN, JR.
A NATIONAL SPACE PROGRAM
REDEFINING THE FUTURE

Space exploration was born of the cold war conflict.

As the traditional cold war backdrop for space development fades into history, a new backdrop of global challenges and domestic goals takes its place. The rationale for future space plans must be examined in this context.

We have had two separate space programs but for all intents and purposes, they were both national security programs. One was conducted secretly and was oriented toward surveillance and strategic deterrence. The other, conducted by NASA, was a national security program in public view. It was open and spectacular -- designed to dazzle the world by its technological might and leadership. The motivation for the manned space program made it as much a part of the "Space Race" as the military program. In fact, it was perhaps the larger part of the "Space Race" because our vulnerability was magnified by our mistakes being as visible as our triumphs.

Although the 1958 space act decreed a space program for peaceful purposes "for the benefit of all mankind," we never really conducted, or even considered, such a program. And let me be quite clear, we could not have carried out a truly benevolent space program in a global atmosphere as tense and combative as that cold war era. We conducted a program for our national survival from which came spin-offs for humankind in medicine, communications, and global understanding.

The United States must adopt a new model for international cooperation. The cold war model of having semi-silent partners -- and paying most of the cost to maintain most of the control -- is obsolete. We must move toward cooperative problem solving and burden sharing. America can no longer support the majority of the costs, and other nations will no longer accept our majority control. In this new time, we have the chance to make a real leap forward for a global effort shared by the industrial nations to explore space.

STATEMENT BY
DANIEL S.GOLDIN,ADMINISTRATOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

On the cooperative agreement between the United States and Russia on Space, Aeronautics and Science.

The joint statements on space, aeronautics and scientific cooperation signed today by Vice President Gore and Russian Prime Minister Chernomyrdin signal a new era for NASA and a new direction for space flight.

For the first time since the dawn of the space age, the conditions that gave rise to space exploration have changed. Our presence on the space frontier began as a product of the cold war, but that ideological struggle is now over. cooperation will replace competition, and a new partnership in space between two former adversaries offers considerable economic advantages for both countries.

Delivered January 26, 1993 at the National Space Club, Washington, DC

The rationale for an international network is based first and foremost on the fact that the Deep Space Network is overloaded resulting in a 50% loss of science data; specifically the Pioneers 10, 11 and 12, Voyagers 1 and 2, and the International Cometary Explorer have suffered significant loss of science data. Second, we assume that spacecraft will need 24-hour communication 7 days per week throughout their primary mission lifetime. Even though advancing technology may reduce this requirement, it has always been necessary to have 24-hour surveillance when there is an indication of a spacecraft problem causing an emergency to be declared. This has occurred on almost every mission flown so far, and late examples are Galileo, Mars Observer, Ulysses, and Magellan. Third, the DSN is limited as follows: 1) each site is subject to a single point of failure due to natural hazards and political. considerations; 2) the current network cannot provide complete coverage of all missions during their encounters with their targets. This leads to the requirement for having latitude diversity while providing redundancy at each longitude. The expediencies encountered during the initial site selection of the current DSN sites caused less than desirable overlap between the longitudinal sites.

The situation is particularly acute regarding the availability of 70m antenna time for both outer planetary missions and for spacecraft emergencies. These emergencies normally require the maximum coverage on earth in order to diagnose and rescue the spacecraft; particularly if there is degradation in spacecraft telecommunications capability such as antenna failures and degradations of power amplifiers, etc. Finally, the current DSN is aging. If we are to keep a viable network, these antennas must eventually be refurbished or replaced. A six-station international network provides interim capability to continue support while the aging DSN is being refurbished.

Candidate Sites

The rationale for recommending particular sites for the additional three deep space communications complexes is as follows: 1) reduces constraints on mission design imposed by the current DSN; 2) examines current sites for relevance to minimum costs to establish the complex. This rationale is based on the effort to improve latitude diversity and to choose longitudinal sites which improve coverage overlap between these sites. Following these precepts leads to these recommendations:

The site at Peldehue near Santiago, Chile at the approximate longitude of Goldstone, California, provides both latitude diversity and the longitudinal location to fill the gap between Goldstone and Madrid which now has very limited overlap. For example, 'if Galileo had proceeded on its X-band mission, a primary science data return from IO would have occurred at the gap between Goldstone and Madrid.' A station at Peldehue would have been perfect. As another example, this site would provide a second southern latitude so urgently needed by Ulysses on its primary mission to the southern pole of the Sun. A southern latitude station enhances the available coverage for mission events of high scientific importance. These events could be scheduled over the southern latitude thereby minimizing the constraint on mission design. Finally, as an alternate to Goldstone, it obviously reduces the susceptibility to earthquakes.

At the longitude of Madrid, I recommend the complex in South Africa originally operated by NASA in the early phases of space exploration and now operated by CNES. It is expected that CNES will become a partner with the other space agencies in missions such as are being developed by the International Mars Exploration Program. This site provides latitude diversity to Madrid and therefore provides an alternate to a natural or political hazard. It is a fully developed site requiring minimum investment in facilities and logistics. It provides additional capability for coverage of spacecraft such as Ulysses at large southern latitudes. Future missions can include high scientific events thus decreasing constraints on mission design. Another alternate to Madrid could be the proposed large antenna project being studied by the Italian Space Agency for implementation on Sardinia or mainland Italy. This would not be as good as South Africa regarding latitude diversity but does provide an alternate to natural hazards and single points of failure at Madrid. At the Canberra longitude, there are several recommendations to be examined. One is the use of Usuda, Japan which already has a 64m diameter antenna. Japan is a partner in international space missions and, in fact, has been used as an alternate site when a mission event was over the northern latitude; specifically, in 1985 telemetry from the International Cometary Explorer encounter with the comet Giacobini-Zinner. Also, in 1989 during the Voyager encounter with Neptune, radio science was enhanced using Usuda as well as the Canberra complex. Another alternate northern latitude is the use of the existing 70m antenna at Ussirisk, Russia. Study should be undertaken to compare the establishment of international complexes at both Ussirisk and Usuda regarding feasibility and costs.

Finally, there are two other sites to be considered for the following reasons: the use of the 70m antenna at Evpatoria in the Ukraine provides coverage over and above the limited overlap between Madrid and Canberra. It also, of course, can be considered as an alternate to a large antenna in either South Africa or Madrid.

<u>Other International Space Activities</u>

For many years, the Consultative Committee on Space Data Systems has been working on inter-network compatibility in all aspects of telecommunications and data acquisition transfer. It involves all the space agencies of the world. Another area of international collaboration fundamental to the telecommunication activities is the International Telecommunications Union of the World Administrative Conferences which reach agreement on allocation of bands for deep space communications. As a step in achieving these agreements, the space agencies have been working in an activity known as the Space Frequency Coordinators Group.

In addition to the advantages of a 6-station network to deep space communications, we are presented with the opportunity to improve contributions to planetary science and astrophysics. The current DSN is already a world-class science instrument. If the additional complexes are maintained at the state of the art of telecommunications, these new sites will also be candidates for world-class science instruments. This would be especially true if the 70m antennas in Russia were included. At present, the only two world-class radar instruments are at Arecibo, Puerto Rico which is primarily a radio observatory, and the Deep Space Communications Complex at Goldstone, California which is the site for the Goldstone Solar System Radar. The additional sites could augment these capabilities if their configurations include 400 to 500 KW uplinks since they already would be equipped with low-noise receivers for telemetry data return. These additional capabilities would reduce the constraints for radar astronomy as now carried out at Arecibo and Goldstone.

The number of space missions from the late 1980s through the 1990s, has grown, therefore, both national and cooperative international mission designs have had constraints on them as follows: 1990-2005, 50% of possible science data lost due to lack of network capacity; 1994, gap in Ulysses coverage; 1995, gap in coverage between Madrid-Goldstone for Galileo; June 28, 1992, seismic activity at Goldstone (DSS 14 out for 1 month); August 5, 1992, lightning at Madrid Complex (all antennas out for 1 day); June-August 1993, bearing failure at DSS 61; Ott-Dec 1993, DSS 14 out for preventive maintenance.

It is evident that the DSN is seriously

overloaded; for example, in-flight missions are NASAa Pioneers 6 through 11, Voyagers 1 & 2, ICE, and Galileo extended mission; funded missions are NASAS Cassini, Pathfinder, & NEAR; ESAs Cassini, Huygens (Titan Probe); Russian Space Agency's Mars 94,96; ISASs Plane B (Mars), Lunar A (Moon); planned missions are NASAs Discovery, Mars Global Surveyor, Pluto Flyby; ESA, Russia and CNES International Mars Exploration Program; and ISASs Soccer.

In order to follow through on the implementation of this proposal, it is suggested these actions be initiated; 1) charter science representatives to establish the impact of an expanded network on the science data return and the enhanced ground-baaed science opportunities; 2) charter a committee to plan implementation schedules and identify funding responsibilities in order to complete the 6-station network by the year 2000. The relevant space agencies are NASA, ESA, ISAS, CNES, IKI, Italian and Canadian Space Agencies.